Synodisms in Chronological Order.

Syn.	Terrestrial. d	h	m	s	*S.* days.	Syn.	Terrestrial. d	h	m	s	*S.* days.
M.J.	0	22	13	42	2·18	E.R.	3	02	48	41	7·13
M.H.	0	23	37	19	2·23	Te.R.	3	05	49	57	7·42
M.Ti.	1	00	02	40	2·30	D.Ti.	3	07	17	47	7·56
M.R.	1	04	35	18	2·72	E.D.	3	10	54	26	7·91
E.J.	1	09	47	46	3·19	R.J.	4	18	58	17	10·96
M.D.	1	10	30	31	3·29	E.Te.	4	23	56	39	11·44
E.H	1	11	02	19	3·34	R.H.	5	15	58	21	12·97
E.Ti.	1	11	58	37	3·43	Te.D.	6	02	01	37	13·92
M.Te.	1	21	11	07	4·25	R.Ti.	6	10	36	42	14·42
Te.J.	1	22	59	43	4·42	D.R.	6	22	39	03	15·89
Te.H.	2	01	29	53	4·71	Ti.J.	19	22	57	41	45·68
Te.Ti.	2	03	23	29	4·87	H.J.	31	00	20	13	70·88
D.J.	2	20	01	59	6·49	Ti.H.	55	23	25	22	128·12
M.E.	3	00	26	43	6·91	⊙ 24625·1 *Sat.* days.					
D.H.	3	02	31	58	7·11						

Fried. Weis published in 1860 *Gesetze der Satellitenbildung* (Perthes, Gotha, 8vo.). In the Library of the Royal Geographical Society.

Nov. 16, 1877.

On a New Astrophotometrical Method. By Prof. Ch. V. Zenger.

It occurred to me to measure the intensity of the light of planetary disks by the time they take appearing or disappearing in twilight, and I first tried it in April, when *Jupiter* was a morning star.

I was surprised at the beautiful regularity and the order in which the details of the planetary disk vanished, and the accordance of the determined intensity of light as well of the four satellites as of the details on the planetary disk.

It is obvious that the time of appearance and disappearance will be different according to the intrinsic luminosity of celestial objects, and that the object will vanish as soon as the heavenly background acquires by reflected light the same intensity as the observed star.

These observations are so easy, and the vanishing of the light is so obvious, that the method will give, even with untrained yet sufficiently sensitive eyes, good results, and will enable every possessor of a telescope from 2 inches aperture upwards to do with it useful work.

Most surprising is the result obtained by this photometrical method in the case of *Jupiter*, enabling us to judge of the relative brightness of the limb, of the planetary centre, of the different parts of the belts and polar zones, and lastly, of the brightness of the Jovian satellites.

It is a known fact, by the measurements of actinic and optic intensity of reflected sunlight from the atmosphere made by Prof. Bunsen and Roscoe, that both give parallel curves of increase and decrease at the same place of observation, and that the intensity is represented by the following formula:—

$$I = a + b \cos z - c \cos^2 z, \tag{1}$$

I denoting intensity of reflected sunlight, a, b, c constants, and z the zenith distance of the Sun.

It is obvious that in our case z is very nearly 90°, and the term $e \cos^2 z$ very small, and we thus get approximately

$$I = a + b \cos z,$$

or

$$i = \frac{I}{a} = 1 + \frac{b}{a} \cos z = 1 + A \cos z, \tag{2}$$

A denoting a new constant, that may be determined by supposing the intensity to become zero when the Sun is 18° below the horizon. We obtain

$$i = 1 + A \cos 108^\circ = 1 - A \sin 18^\circ = 0,$$

and therefore

$$A = 3{\cdot}2361 \tag{3}$$

By a known formula we obtain

$$\cos z = \sin \delta \sin \phi + \cos \delta \cos \phi \cos t = \cos \phi \cos \delta (\cos t + \tan \phi \tan \delta),$$

or

$$I = 1 + 3{\cdot}2361 \cos \phi \cos \delta (\cos t + \tan \phi \tan \delta). \tag{4}$$

Supposing the Sun's declination to be $\delta = 0$, and $t = 90^\circ = 6^h$, we obtain, in equinoctial time, the Sun being in the horizon, $I = 1$, the unit for photometrical measurement.

Tab. 1.—It is from the above formula (4) I calculated a table to give, by interpolation, the brightness of twilight for Sun's declination $= +20^\circ$ to -20° and $t = 4^h$ to $t' = 8^h$.

Tab. 2.—The second table gives the observations of *Jupiter* April 1877 to end of October, containing time of appearance and disappearance of Jovian details and satellites with a 4-inch equatoreal, power 56 to get a large field.

Tab. 3.—It is obvious that the condition of the atmosphere will affect the absolute time of disappearance and appearance,

but not the relative time of it; I therefore computed the brightness relative to the third satellite, which gave the least variations of brightness of all in the Jovian system. The results are given in the third table.

The result is that the order of Jovian details, as shown by the means of observed brightness, will be as follows:—

First in brightness was observed the northern limb of the planet's disk, near the equator, then follow the middle part of the northern equatoreal belt, the northern polar zone, the southern belt (middle part of it), the southern polar zone; next to it comes the third satellite, its brightness differing only 5 per cent. from the brightness of the planetary disk near the southern pole, the second and first satellites both very nearly of the same brightness, yet sometimes interchanging in brightness, and finally the fourth satellite, the weakest in brightness, yet very variable, attaining sometimes nearly the brightness of the second satellite, yet decreasing to nearly one-half of the brightness of the third satellite.

The means, computed as shown above, are:

		Satellites.	
Limb of planetary disk	1·555		
Equatoreal belt, N.	1·130	Third	1·000
Polar zone, N.	1·124	Second	0·970
Equatoreal belt, S.	1·110	First	0·961
Polar zone, S.	1·091	Fourth	0·820

A period of change of brightness seems to be indicated with the fourth and second satellites, the period being as a mean for the former 16·6 days, for the second nearly two days, both in accordance with the time of revolution. The small number of observations, and, still more, the small amount of change in the first and third satellites did not allow of deducing periods of change of brightness for these. As *Venus* becomes now visible for the smallest telescopes during daylight, it would be interesting to apply this method of observation to the planetary details, so as to determine the influence of reflecting power, apparent breadth of illuminated disk, and distance, the time of appearance of light, if any there be, on the dark part of disk, etc. The method being so plain, and requiring no apparatus for photometric measurement, I supposed it of interest to any possessor of a telescope from 2 inches upwards.

Prague, Oct. 17, 1877.

On the Relative Brightness of the Details of Jupiter's Disk and Satellites.

TABLE I.

Hour Angle.				*Intensity of Twilight.* ☉'s Declination.									*Cosines of Zenith Distances.*								
h	m	°		−20°	Δ1°	−10°	Δ1°	0°	Δ1°	+10°	Δ1°	+20°	−20°	Δ1°	−10°	Δ1°	0°	Δ1°	+10°	Δ1°	+20°
4	0	60	0	1·124		1·570		2·000		2·398		2·757	+0·040		−0·183		+0·321		0·449		+0·564
					0·045		0·043		0·040		0·036			0·014		0·014		0·013		0·011	
	40	70	0	0·850		1·258		1·680		2·087		2·458	−0·056		−0·083		0·219		0·349		0·468
					0·041		0·042		0·041		0·037			0·002		0·014		0·013		0·011	
5	20	80	0	0·504		0·926		1·345		1·753		2·141	−0·159		−0·024		0·111		0·242		0·366
					0·042		0·042		0·041		0·041			0·014		0·014		0·013		0·012	
6	0	90	0	0·183		0·586		1·000		1·414		1·815	−0·262		−0·133		0·000		0·133		0·262
					0·040		0·041		0·041		0·040			0·013		0·013		0·013		0·013	
	40	100	0	...		0·246		0·655		1·074		1·796	−0·365		−0·242		−0·111		0·024		0·159
							0·041		0·042		0·042			0·012		0·012		0·013		0·013	
7	20	110	0	...		...		0·318		0·745		1·175	−0·468		−0·349		−0·219		−0·082		0·056
									0·042		0·043			0·012		0·012		0·014		0·014	
	0	120	0	...		...		0·000		0·430		0·879	−0·564		−0·449		−0·321		−0·183		0·039
									0·043		0·045			0·012		0·012		0·014		0·014	

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Table II.

Date.	The Satellites. (4)	(3)	(2)	(1)	Equatoreal Belts. South Limb.	South Middle.	North Limb.	North Middle.	Polar Zones. South.	North.	Limb of Disk.	Two Fixed Stars near *Jupiter's* Sat. (4).
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
April 7	17 8·0	17 17·5	17 11·0	17 16·0	17 42·0	17 44·0	17 46·0	17 59·0	18 0·75	18 15·0	18 25·5	...
June 12	15 16·0	15 26·1	15 24·1	15 21·0	...	...	...	...	...	...	...	...
„ 14	15 20·8	15 30·1	15 23·75	15 26·7	...	...	...	...	...	...	...	...
Sept. 11	6 39·0	6 26·0	6 28·0	6 36·0	...	6 15·0	...	6 25·0	6 19·0	6 25·5	...	...
„ 28	6 30·0	5 47·0	6 0·25	5 48·25	...	5 42·0	...	5 42·0	5 54·0	5 45·0	...	6 43·0 F_1
„ 30	6 35·0	5 54·25	5 56·5	6 1·0	...	5 40·0	...	5 40·0	5 48·0	5 45·0	...	6 37·0 F_1
Oct. 6	5 55·5	5 42·25	5 44·5	5 43·5	...	5 28·0	...	5 28·0	5 32·5	5 31·0	...	6 15·0 F_2
„ 7	5 46·25	5 36·5	...	5 39·0	...	5 26·0	...	5 26·0	...	5 28·5	...	6 14·0 F_2
„ 14	5 58·5	5 28·0	...	5 34·5	...	5 17·0	...	5 15·0	5 27·0	5 21·0	...	6 2·0 F_2
„ 21	5 15·0	5 37·5	5 8·25	5 6·25	...	4 50·0	...	4 52·5	...	4 56·0	4 45	...
„ 27	5 5·3	4 56·2	4 57·4	4 59·0	...	5 53·5	...	4 53·0	5 4·5	4 50·3	...	...

Table III.

Equinoctial Twilight—1·000 at 6^h.

Date.	(4)	(3)	(2)	(1)	South Limb.	South Middle.	North Limb.	North Middle.	South.	North.	Limb of Disk.	Two Fixed Stars.
April 7	0·805	0·891	0·800	0·877	1·102	1·120	1·138	1·206	1·280	1·408	1·502	...
June 12	0·751	0·870	0·848	0·811		...		...	...	...	...	...
„ 14	0·753	0·806	0·769	0·787		...		...	...	...	...	...
Sept. 11	0·816	0·933	0·925	0·846		1·032		1·032	0·938	1·014	...	...
„ 28	0·588	0·934	0·926	0·828		0·974		0·974	0·878	0·950	...	0·486 F_1
„ 30	0·538	0·900	0·881	0·834		1·052		1·052	0·977	1·005	...	0·481 F_1

TABLE III.—*continued.*

Date.	The Satellites. (4)	(3)	(2)	(1)	Equatoreal Belts. South Limb.	South Middle.	North Limb.	North Middle.	Polar Zones. South.	North.	Limb of Disk.	Two Fixed Stars near *Jupiter's* Sat. (4).
Oct. 6	0·769	0·835	0·825	0·817		0·949		0·949	0·913	0·925	...	0·573 F_2
„ 7	0·864	1·014	...	1·004		1·056		1·056	...	1·046	...	0·632 F_2
„ 14	0·884	0·937	...	0·929		1·027		1·043	1·027	1·043	...	0·654 F_2
„ 21	0·935	1·055	1·014	1·032		1·149		1·127	...	1·127	1·059	...
„ 27	0·941	1·023	0·996	0·979		1·027		1·033	1·029	1·033	...	...
Means:	0·785	0·914	0·880	0·791		1·043		1·053	0·962	1·063	1·280	0·484
Sat. (3) = 1·000:	0·855	1·000	0·939	0·862		1·141		1·152	1·053	1·163	1·401	0·620
April 7	0·91	1·000	0·93	0·99		1·25		1·32	1·43	1·43	1·86	...
June 12	0·85	1·000	0·97	0·93		...		...	...	...	...	...
„ 14	0·93	1·000	0·95	0·98		...		...	...	...	...	...
Sept. 11	0·88	1·000	0·99	0·91		1·10		1·10	1·00	1·08	...	...
„ 28	0·62	1·000	0·99	0·94		1·03		1·03	0·94	1·01	...	0·52
„ 30	0·60	1·000	0·97	0·92		1·17		1·17	1·08	1·16	...	0·53
Oct. 6	0·91	1·000	0·99	0·98		1·14		1·14	1·02	1·04	...	0·67
„ 7	0·85	1·000	...	0·99		1·04		1·04	...	1·03	...	0·62
„ 8	0·95	1·000	...	0·99		1·10		1·11	1·09	1·11	...	0·69
„ 21	0·89	1·000	0·96	0·98		1·09		1·07	...	1·07	1·25	...
„ 27	0·92	1·000	0·97	0·97		1·01		1·02	1·01	1·02	...	0·525
Means:	0·840	1·000	0·970	0·961		1·110		1·130	1·091	1·124	1·555	0·655